What is claimed is:

1. A system for processing a workpiece, comprising:

(A) a plasma immersion ion implantation reactor, comprising:

(1) an enclosure comprising a side wall and a ceiling and defining a chamber;

(2) a workpiece support pedestal within the chamber having a workpiece support surface facing said ceiling and defining a process region extending generally across said wafer support pedestal and confined laterally by said side wall and axially between said workpiece support pedestal and said ceiling;

(3) said enclosure having at least a first pair of openings at generally opposite sides of said process region;

(4) a first hollow conduit outside of said chamber having first and second ends connected to respective ones of said first pair of openings, so as to provide a first reentrant path extending through said conduit and across said process region;

(5) gas distribution apparatus on or near an interior surface of said reactor for introducing a process gas containing a first species to be ion implanted into a surface layer of said workpiece;

(6) a first RF plasma source power applicator for generating a plasma in said chamber;

(B) a second wafer processing apparatus;

(C) wafer transfer apparatus for transferring said workpiece between said plasma immersion ion implantation reactor and said second wafer processing apparatus.

2. The system of Claim 1 wherein said second wafer processing apparatus comprises a cleaning species source plasma reactor comprising:

(1) a source of cleaning species precursor

gases;

(2) a passage coupling said cleaning species source plasma reactor to said plasma immersion ion implantation reactor.

3. The system of Claim 2 wherein said cleaning species precursor gases comprise a fluorine-containing species.

4. The system of Claim 2 wherein said cleaning species precursor gases comprise a hydrogen-containing species.

5. The system of Claim 1 wherein said second wafer processing apparatus comprises:

an optical metrology chamber for obtaining a measurement of ion implantation in a workpiece;

a process controller coupled to receive measurements from said optical metrology chamber for controlling said plasma immersion ion implantation reactor.

6. The system of Claim 1 wherein said second wafer processing apparatus comprises:

an ion beam implantation apparatus for ion implanting a second species into said surface layer of said workpiece.

7. The system of Claim 6 wherein said surface layer is a semiconductor material, and said first and second species are dopant impurities of opposite conductivity types relative to said semiconductor material.

8. The system of Claim 1 wherein said second wafer processing apparatus comprises:

a second plasma immersion ion implantation reactor for ion implanting a second species into said surface layer of said workpiece.

9. The system of Claim 8 wherein said surface layer is a semiconductor material, and said first and second species are dopant impurities of opposite conductivity types relative to said semiconductor material.

10. The system of Claim 1 wherein said second wafer processing apparatus comprises an anneal chamber.

11. The system of Claim 1 wherein said second wafer processing apparatus comprises:

a photoresist strip chamber.

12. The system of Claim 1 wherein said second wafer processing apparatus comprises a wet clean chamber.

13. The reactor of Claim 1 wherein said plasma comprises a plasma current in said reentrant path that oscillates at an RF frequency of said first RF plasma source power applicator.

14. The reactor of Claim 1 wherein said first hollow conduit comprises a metal material, said reactor further comprising:

an annular insulating gap in said first hollow conduit separating said first hollow conduit into axial sections.

15. The reactor of Claim 1 wherein said ceiling comprises a constriction of said reentrant torroidal path in said process zone for enhancement of plasma ion density of said plasma current in said process zone.

16. The reactor of Claim 1 wherein said ceiling and said wafer support pedestal are separated by a gap therebetween, said gap being sufficiently small so that

plasma ion density of said plasma current is greater in the vicinity of said workpiece support pedestal than elsewhere along said rentrant path.

17. The reactor of Claim 1 wherein the workpiece support pedestal comprises an electrostatic chuck, said electrostatic chuck comprising thermal control apparatus for workpiece temperature control.

18. The system of Claim 1 further comprising a bias source coupled to said workpiece support.

19. The reactor of Claim 18 wherein said bias source comprises an RF bias generator having an RF bias frequency sufficiently low to enable ions traversing the plasma sheath to attain an energy corresponding to a peak-to-peak voltage of said bias power generator.

20. The reactor of Claim 19 wherein said RF bias frequency is sufficiently high to limit RF voltage drops across dielectric layers on said workpiece support pedestal to less than a predeterminded fraction of plasma sheath voltage near said workpiece support.

21. The reactor of Claim 20 wherein said predetermined fraction corresponds to about 10%.

22. A system for processing a workpiece comprising a plurality of plasma immersion ion implantation reactors, each of said plasma immersion ion implantation reactors comprising:

(1) an enclosure comprising a side wall and a ceiling and defining a chamber;

(2) a workpiece support pedestal within the chamber having a workpiece support surface facing said ceiling and defining a process region extending generally

across said wafer support pedestal and confined laterally by said side wall and axially between said workpiece support pedestal and said ceiling;

(3) said enclosure having at least a first pair of openings at generally opposite sides of said process region;

(4) a first hollow conduit outside of said chamber having first and second ends connected to respective ones of said first pair of openings, so as to provide a first reentrant path extending through said conduit and across said process region;

(5) gas distribution apparatus on or near an interior surface of said reactor for introducing a process gas containing a first species to be ion implanted into a surface layer of said workpiece;

(6) a first RF plasma source power applicator for generating a plasma in said chamber.

23. The system of Claim 22 further comprising a wafer handling apparatus coupled to each of said plurality of plasma immersion ion implantation reactors.